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Carlo Mazzaferro, Marcello Morciano

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Università di Modena e Reggio Emilia Facoltà di Economia Marco Biagi

Università di Bologna Dipartimento di Scienze Economiche

CAPP - Centro di Analisi delle Politiche Pubbliche
Dipartimento di Economia Politica - Università di Modena e Reggio Emilia
Ufficio 54 - Ala Ovest
Viale Berengario, 51 41100 Modena - ITALY
phone: +39 059 2056854 fax: +39 059 2056947
email capp@unimo.it

CAPP_DYN: A Dynamic Micro-simulation Model for the Italian Social Security System

Carlo Mazzaferro [1] and Marcello Morciano [2*]

[1] Department of Economics, University of Bologna; CAPP and CHILD
[2] Health Economics Group, University of East Anglia (UK); CAPP and ISER (UK)

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Abstract
Microsimulation allows to apply a set of deterministic or stochastic rules on a sample of micro-unit such as individuals, households, firms or institutions. A Dynamic Microsimulation Model (DMM) contains a set of rules aiming at projecting the likely socio-economic evolution of a representative sample of individuals throughout time. In this paper, we describe the simulation algorithms and the econom(etr)ic frameworks used in CAPP_DYN, a population based DMM for the analysis of the inter- and intra-generational redistributive effects of the Italian social security system. By including detailed rules that determine the eligibility to various social security benefits, CAPP_DYN is qualified as a useful tool in assessing the long-run distributional effects of the reforms approved in the Italian social security system.

Keywords: Dynamic Microsimulation; Pensions; Long-term care.
JEL Classifications: C1 C5 H55.

*Corresponding author: Marcello Morciano, Norwich Medical School, University of East Anglia, Norwich, NR4 7TJ, United Kingdom. E-mail: m.morciano@uea.ac.uk

1 Introduction

Reforms of the social security system typically exerts most of their effect in the medium-long run. So far, at least in Italy, the empirical research and the economic policy debate have devoted more attention to the macroeconomic and financial effects of such reforms, providing less attention to the (re)distributive viewpoint. Official macro projections made annually available by the Italian Department of General Accounts (RGS, 2011) are important examples of this approach. The complexity in the eligibility criteria for retirement, rules for computing pension earnings, and non-linearity induced by means testing of many social security benefit programs makes the analysis at individual-level not straightforward. Besides, the interaction of the social security system with the demographic and economic developments of a population makes conventional analytic methods inadequate for distributive analysis on future pension incomes (Pudney, 1992). Dynamic simulation at the micro-level must be used instead.

Starting with the seminal contribution of Orcutt Orcutt (1957) and his collaborators, microsimulation techniques have been extensively used in policy analysis (Citro and Hanushek, 2001; Harding, 1993; O'Donoghue, 2001; Bourguignon and Spadaro, 2006; Harding, 1996; Harding and Gupta, 2007; Mitton, Sutherland, and Weeks, 2000; Gupta and Kapur, 2000; O'Donoghue, 2010). A micro-simulation model (MsM) is essentially composed by a set of deterministic or stochastic rules, applied on a sample of micro-units (Klevmarken, 2005). Micro-units can represent single individuals, households, firms or institutions whose characteristics are drawn from survey or administrative data or generated artificially. Micro-units can be treated independently or may interact each others. Rules provide a simplified representation of the "reality" the model intend to represent[1] and changes of them allows to examine '*what would happen if*" a certain reform were implemented.

Dynamic Micro-simulation Models (DMMs) simulate the interaction of each micro-unit with the welfare system over a sample of micro-units which evolve over time. In contrast with static simulation, which provides a simple snapshot at a certain point in time, dynamic simulation is a process by which sample information of the micro-units collected at a certain point in time are "aged" over time, building up a synthetic longitudinal database. At each point in time, policy parameters are applied. In contrast with traditional macro-economic models, a DMM provides, under certain assumptions, disaggregated information, such us the whole distribution of the variable of interest as well as sample means, which are critical for making distributive analysis. A DMM allows to make both simple prediction under conditions of unchanged policy and demographic/economic trends and also assess the effects

[1]In a static tax/benefit model, for example, the typical simulation algorithm is in the form of "program codes" with which legislation in force and parameters of the tax/benefit system are applied. If a certain policy parameter x (i.e the eligibility criteria for a benefit) change then y (i.e. disposable income) will change accordingly.

of changes in government policy or/and in demographic and economic trends. The greatest advantage of adopting a micro-level approach is that problems of heterogeneity, averaging and aggregation bias (common in macro-economic models) can be avoided. Managing the distribution of the variable of interest and not only its (conditional or unconditional) sample mean is critical for making distributive analysis.

In spite of its countless advantages, micro-simulation is not free from criticisms. Reliability of MsM predictions, which are essentially statistical estimates (Pudney and Sutherland, 1994), depends on the accuracy of simulation algorithms and on the quality of the data in use. Since MsMs rely on reduced form relations that are not invariant to changes in the economic, demographic and institutional environment, they have been criticized for being less trustworthy than other models. The autonomy and stability of the model structure to exogenous change need to be validated carefully.[2] Finally, appropriate documentation on the (rather complex) model functioning is often lacking, so that to an outside researcher the model works as a "black box" (Dekkers, 2010).

Despite the above-mentioned criticisms, DMMs have been commonly used to analyze the long-term perspective of social security systems in countries like North America, North Europe and Australia (see Li and O'Donoghue, 2012; Zaidi and Rake, 2001; O'Donoghue, 2001, for a review). However, their use in Italy is recent and not completely developed. Beside, Italy has a complex and wide-spread welfare state system. Its Social Security system is facing an intense pressure on the demographic side and it has been subjected, since 1993, to radical reforms which will produce important effects mainly in the medium and long-run. Notwithstanding research on the redistributive implications of such reforms in the context of the greying process of the Italian population is still little developed[3].

This paper describes the latest version of CAPP_DYN, a population-based DMM for the analysis of the inter- and intra-generational redistributive effects of the Italian social security system. CAPP_DYN, considered one of the most advanced population-based DMM in the EU (TARKI, 2009), comes up within a research project carried out by the *Centre for*

[2]However, Klevmarken pointed out that '*is not easy to know if a model is sufficiently stable to permit the analysis of a certain change in policy*" (Klevmarken, 2005, ; p. 36).

[3]The first DMM for the Italian economy, DYNAMITE (Ando and Nicoletti-Altimari, 2004) was developed at end of the 1990s within a Bank of Italy research project. It was employed mainly to analyze the effects of demographic transition and Social Security reforms on private savings. Following this work, Vagliasindi (2004) developed MINT, a DMM which analyses the medium-long run distributional effects of the pension system and the medium term redistributive impact of changing in personal income taxation. Both these models are not currently being in use. More recently, in a joint project with Belgian and German research teams, ISAE developed a DMM model based on a previous version of LIAM, a DMM for the Irish society. Finally, two important example of cohort models are: *CeRPSIM2* designed to analyse the distributional feature embedded in the Italian pension system during its transition from the old DB system to an NDC system (Borella and Moscarola, 2010) and *LABORsim* an agent-based model designed to make projections on the likely evolution of the Italian labour force (Leombruni and Richiardi, 2006).

the Analysis of Public Policies (CAPP)[4] under the auspices of the European Commission and the Italian Department of Employment and Social Policies with the aim of assessing the distributional effects of reforms adopted in the Italian pension system (Ministero del Lavoro e delle Politiche Sociali, 2005; EU, 2011). Previous versions of the model have been used –among others- in assessing the extent of the redistribution of lifetime earnings operated by the Italian pension system (Mazzaferro and Morciano, 2011; Mazzaferro, Morciano and Savegnago, 2012) and the long-run distributive implication of the Italian Long-Term Care system (Baldini, Mazzaferro, and Morciano, 2008).

This paper is organised as follow. Section 2 introduces the simulation approach in use. Section 3 presents general features of the model. Following sections are devoted to present the main modules of the model with the goal of describing simulation algorithms and the underlying econom(etr)ic framework employed.

2 The dynamic modelling approach

In a DMM the initial population is generally "aged" over time by means of *dynamic ageing* procedures.[5] Such procedures can be either probabilistic or deterministic. In CAPP_DYN we simulate deterministically some events (i.e. the ageing of the sample members; the application of eligibility criteria for retirement and computation of pension benefits) whereas others (i.e. individuals' demographic and labour market trajectories, earnings and so on) are simulated stochastically.

For the purpose of illustrating the principles involved, let define a particular life-course event τ, partitioned into K mutually exclusive states. For instance, τ can be the event "death" which has two mutual exclusive states ("alive" and "dead"). The probability p_{ij} that a micro-unit will experience a transition from the state i in time t to the state j in time $t+1$ (with $i,j=1,\ldots,K$), can be expressed as follow:

$$p_{ij} = Prob\left(\tau_{t+1} = j | \tau_t = i\right) \tag{1}$$

More generally, transition probabilities can be represented by a strictly positive matrix, called *transition matrix*:

[4] http://capp.unimo.it/indexEN.html

[5] There are two approaches in ageing a population. An alternative to the dynamic ageing one is the dynamic re-weighting or stating ageing approach. This is done by altering the weighting factors attached to each micro-unit, conditional on a set of observable characteristics. Weights are generally aligned with macro-level forecasts of relevant aspect of the population is intended to represent. This approach is often used in static models in attempting to age the original cross-section sample by few years to overcome the fact that sample surveys are usually a little out of date, due to infrequent surveys or to the delay which occurs before micro-data are realized for public use (Harding, 1990).

$$P_{n\times m} = \begin{bmatrix} p_{11} & \cdots & p_{1m} \\ \cdots & p_{ij} & \cdots \\ p_{n1} & \cdots & p_{nm} \end{bmatrix} \tag{2}$$

where the n rows (m columns) identify the space of events in year t (t+1). The ith row of the transition matrix $\begin{bmatrix} p_{i1} & \cdots & p_{im} \end{bmatrix}$, called *probability vector*, represents the probability of all possible transitions from i into whatever else state j in the space of the states. Matrix P has the following properties:

- it is a square matrix, the number of states being the same in period t and t+1 (i=j);
- $0 \le p_{ij} \le 1 \qquad$ for all $i, j \in K$;
- $\sum_{j=1}^{m} p_{ij} = 1 \qquad i = 1, \ldots, n$ and j=1,...,m;
- the elements in the main diagonal (i=j) represent the probabilities of inertia.

Elements in (2) can be in the form of conditional[6] or unconditional probabilities and can be derived from aggregated data or they can either be estimated from micro-data.

Once the transitional probabilities for event τ are attached at each micro-unit at a certain point in time, a Monte Carlo process allows to simulate the event. Namely, a event specific random number (u) drawn from a uniform distribution with support [0,1] is attached to the record of every individual. The state j is finally assigned according the formula:

$$\sum_{j=1}^{K}(p_{ij-1}|i) \le u \le \sum_{j=1}^{K}(p_{ij}|i) \tag{3}$$

3 CAPP_DYN: General Features

CAPP_DYN simulates the socio-demographic and economic evolution of a representative sample of the Italian population for the period 2007-2050. The base year population is derived from a large and representative sample of the Italian population which provides a snapshot at a given point in time. As time passes, all individuals in the sample are involved in a considerable number of demographic and economic events. Such events are simulated in discrete time (annual cycle) using event-specific Monte Carlo processes. Thus, to model a change in the socio-economic characteristic of a sample member from one year

[6]Often, economic theory suggests that transition probabilities varies according micro-unit characteristics such as gender, age, level of education and so on. As it will appear clear in the following sections, behavioral relations can be easily introduced in the simulation algorithm using estimates obtained by econometric models.

to the next we first fit to the data statistical models that capture all relevant aspects of the individual's transitions; then, we simulate change in the individual status by making random drawings from the estimated models. Transition probabilities are conditional on a set of individual characteristics and are obtained from a range of available data source (see Table 1). Once the population structure has been defined and labour earnings have been generated the model simulates the interaction of sample members with the Social Security system, the latter modelled with a high level of institutional detail and according to the pension scheme provision being in force.

According to the taxonomy proposed by O'Donoghue (2001), CAPP_DYN presents the following features:

- It is a *closed* model: it simulates life-cycle evolution of the main demographic and economic population features. New individuals enter in the population each year due to birth and net inflows migration, while others exit due to death.
- It is a *dynamic ageing* model: individual characteristics are yearly up to dated thanks to dynamic ageing processes which make use of transition probabilities among states.
- It is a *discrete time* model: transitions among states are simulated at yearly base.
- The ageing process is *probabilistic*: statistical models are employed in deriving transition probabilities. Given a particular event, partitioned into a number of mutually exclusive states at each point in time, transitions among states are simulated using discrete Markovian processes and applying *Monte Carlo* procedures.
- While the unit of simulation is the individual, the model keeps information on household structure and any changes this may be subjected to over the course of time. Therefore, the unit of analysis can be both individuals and households.

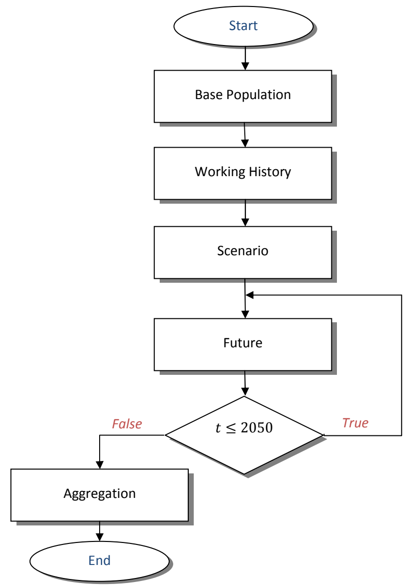
CAPP_DYN is structured in five blocks as shown in Figure 1.

The *base population* block holds the procedures needed to generate the base year population (i.e. the representative sample of individuals of the first year of the simulation). Socio-economic information for the sample units are drawn from the Italian component of the 2007 European survey *Statistics on Income and Living Conditions* (IT-SILC)[7]. IT-SILC collects annually a comprehensive set of socio-demographic and income information of respondents (ISTAT, 2008a) and it is considered the most suitable source of data for our purposes because of: *i)* its large sample size (52,772 individuals in 20,982 households were interviewed in the 2007-wave); *ii)* its longitudinal features; and *iii)* the integration of income information provided by interviewees with administrative records (ISTAT, 2009).

The CAPP_DYN initial sample is drawn from cross-sectional data. In order to calculate

[7]We refer to Ciani and Fresu (2011) for a detailed description of the most important features of the data, its representativeness and the procedures adopted in deriving the base year population.

Figure 1: The structure of CAPP_DYN



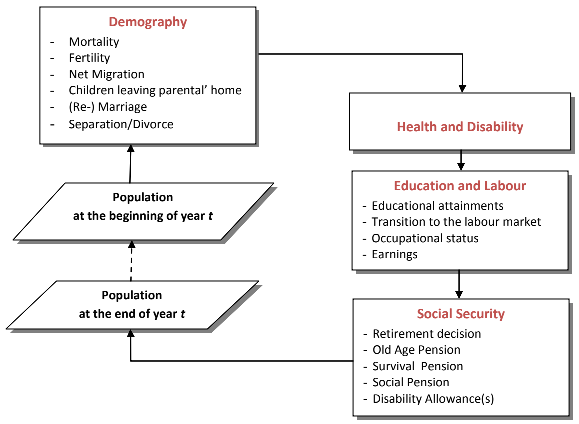
future pension entitlements for those already in the labour market at the time were IT-SILC data were collected, we need to reconstruct the past working histories of those members with working experience, since his/her entry into the labour market. The back-casting of work histories is done in the *working history* block, using all the retrospective information collected in the IT-SILC[8].[9] CAPP_DYN makes projections (and not forecasts) based on specific assumptions on the socio-demographic and economic trends expected for the future. In the *scenario* block user can define the exogenous parameters of the model. Specifically, this block allows the definition of the dynamic paths of demographic (mortality, fertility and migration) and macroeconomic (GDP and earnings growth) under which projections are valid. The *future* block is the core of the model. It contains algorithms aiming at simulating yearly changes in the socio-economic characteristics of the micro-units. The set of events simulated can be grouped into four main modules, applied *sequentially* and *recursively*[10] according the structure in Figure 2. At the end of each yearly process a

[8] We mainly exploit information regarding contributory seniority, professional attainments and sectors (actual and previous) taken from the IT-SILC. The life-cycle profile of past earnings is built using the same procedure in use for forecasting earnings. Individual earnings are then discounted by an annual variable rate amounting to the growth of real earnings observed in the period 1952-2006. Values 1952-2001 are provided by Prof. Roberto Golinelli. Values for the period 2001-2006 are obtained from ISTAT data. See Ciani and Fresu (2011) for details.

[9] See O'Donoghue (2001) for a review of the different approaches used in many DMMs in "back-casting" work histories.

[10] The first feature means that modules (events) are simulated using a prefixed order rather than allowing

Figure 2: Events simulated by CAPP_DYN



cross-section is produced representing the population at a particular point in time. The set comprising T annual cross-sections is aggregated in the *aggregation* block, producing a synthetic panel containing the socio-economic information of interest for the entire sample population in the simulated period $t=1\ldots T$.

Following sections describe the set of modules composing the *future* block. Namely, demography (Section 4); health and disability (Section 5); education and labour market (Section 6); and social security (Section 7). Table 1 shows the list of events simulated in CAPP_DYN and for each of them, it synthesizes the main features of the simulation alghoritm, the econometric framework employed for estimating the conditional transition probabilities and data source.

4 The demographic module

Demographic events can be divided in two groups: *external* events, which modify the population structure by age, gender and geographical area; and *internal* events, which affect the household structure only. Ageing, mortality, fertility and immigration are included in the former group, while exit from the family unit, marriage and divorce are part of the latter.

First, external events are simulated. Each yearly loop ages the population by one year. Then, simulation goes on in determining the number of observations that exit the model

the definition of a random sequence in each of the simulated year. The second implies that, once all the modules have run for period t, the model does the same for period $t+1$ and so on ($t=1,\ldots,T$).

Table 1: The range of events simulated by CAPP_DYN: data source, methods and set of socio-economic observable characteristics

Events	*Data source*	*Method and set of covariates*
Mortality	ISTAT official projections 1/1/2007	Official mortality rates (conditional on age, gender, year of simulation and area of residence) are applied to all members in the sample in each year of simulation
Fertility	ISTAT official projections 1/1/2007; ISTAT "*Famiglie, Soggetti Sociali e Condizioni dell'Infanzia*" 2003.	Fertility rates conditional on age and year of simulation are applied to married women aged 16-49. The flow of newborns is allocated within households in the sample conditional on mother age, giving a decreasing probability according the number of previously born children.
Net Migration	ISTAT official projections 1/1/2007; ISTAT "*Permessi di soggiorno*" [http://demo.istat.it/altridati/permessi/] IT-SILC (2007).	The flow of new immigrants is determined according official projections, conditional on year of simulation. The flow is simulated having age, gender and area of residence distributions similar the ones observed among current (new) immigrants. Age of new entrants is restricted in the 16-65 age bands.
Leaving parental' home (Re)marriage Divorce	ISTAT "*Famiglie e Soggetti Sociali*" (2003, 2005).	Transition probabilities by age group, gender and area of residence. (Re)marriage simulated using propensity score matching technique according age groups, gender, area of residence, education and previous marital status of the candidates. Age restriction imposed (see text for details)
Health/Disability	ISTAT "*Indagine sulle Condizioni di Salute*" (2005)	Estimates of an ordered probit model are used. Level of disability is regressed on over a set of socio-economic (SES) characteristics to account for the gradient between disability and SES. Splines of age are also included as regressors.
Education	IT-SILC (2005).	An ordered probit model allows to links educational attainments with a set of covariates which includes, amongst others, family background indicators (measured when pupils aged 15).
Entry into the labour market Transitions between labour and non labour statuses	ISTAT, RTFL (1993-2007).	Gender specific multinomial logit models where transitions from/to states are regressed on polynomial of age, area of residence, cohort of birth, marital status, education, contributory seniority and so on.
Earnings	IT-SILC (2004-2007).	Different log OLS models where yearly earnings depend on polynomial of age and contributory seniority, gender, area of residence, citizenship, education, professional qualification, work time (part time/full time), sector. We model auto-regressive disturbances using the panel component of IT-SILC.
Social Security	Eligibility criteria, computational formulas and means test rules are retrieved from a variety of official sources.	Eligibility criteria, computational formulas and means test rules are those in force in 2012 (March).

due to death and the flow of new births. Besides, yearly population size is increased by the simulation of migration. Although the structure of CAPP_DYN is sufficiently flexible in accommodating different assumptions, demographic trends in use are consistent with the main variant of official population projections, made available by the National Statistic Institute (ISTAT).

Once population size and its composition have been defined for each period, the model starts the simulation of processes modifying the structure and the composition of household units. Children between 18 and 34 can leave their household unit of origin in order to establish an independent household. Singles, living or not with their parents, can get married. The marriage event determines the creation of a new household unit.[11] Finally, the model simulates divorce for a share of married people, determining the split of the previous household unit.

4.1 Mortality

ISTAT provides a complete set of mortality rates by age and gender for the next four decades. It is worth reminding that official projections are obtained employing an cohort component model, widely used in all the developed countries, which projects a decreasing death probability across all ages and a substantial increase in old age survival probabilities (ISTAT, 2008b). According the latest projections, life expectancy at birth in the period 2007-2050 will increase of about 5.9 years for males and 5.4 years for female, reaching 84.5 years and 89.5 years, respectively.

The simulation algorithm of the mortality module works as following: conditional on the year of simulation and the age and gender of each sample member, a random number is drawn from a uniform distribution [0,1] is attached to each observation. Following equation (3), if the sample member random value in time t is smaller than the age-gender specific official death probability for t, then the model simulates death and consequently modifies the cohabitant's marital status. Otherwise, the model ages the observation by one year. A special routine in CAPP_DYN allows to take account differential mortality by socio-economic status proxied by individual's educational attainment.[12]

4.2 Fertility

Italy is experiencing one of the lowest Total Fertility Rate (TFR)[13] in the word (Perez and Livi-Bacci, 1992) in 1960, TFR was 2.41; by 2007 it had fallen to 1.37. According to

[11] Widowed or divorced/separated individuals can get married, following the same rules applied to singles

[12] See Mazzaferro, Morciano and Savegnago (2012) for details.

[13] TFR measures the average number of children per woman.

official projections, by 2050 Italy will be the second oldest country in the word, even if the TFR is projected to slight increase up to 1.58.

While we reproduce the aggregate early flow of newborns found in official projections, the probability that a women of child-bearing age (16-49) would have a child in t is conditional on her age and the number of children already had. In detail, CAPP_DYN ranks women in a decreasing order according their probability of having a child. Letting $f_a(c)$ be the probability distribution function for a married woman aged a with a number of previously born children equal to c, the probability of having a new child in year t for that woman is:

$$P\left(c_t = c_{t-1} + 1 | a_t, c_{t-1}\right) = \left(1 - F_{a_t}(c_{t-1})\right)$$

where $F_{a_t}(c_{t-1})$ is the cumulative distribution function of $f_{a_t}(c_{t-1})$. The flow of newborns is therefore allocated within households in the sample conditional on mother age, giving a decreasing probability according the number of previously born children.

If childbirth is simulated to occur, then a new data record is created in which the year of birth, a new identifying number, and the household identifying number are all recorded. Household unit size and composition are automatically updated. The newborn's sex is assigned randomly, probability to be male or female being the same. The future lives of the newly-created children are then simulated on a year-by-year basis, applying modules in figure (2).

4.3 Immigration

In the official demographic forecasts, the most "unstable" component is the one which concern migration. It has been noticed that forecasts on migrations have a high degree of uncertainly due to the fact that mobility of populations has being affected by social, economic, psychological and political factors all of which are hardly predictable (Blangiardo, 1997).

ISTAT forecasts that the net expected migration flow for the next decades converges to a bracket between 195,000 to 200,000 individuals each year.[14] CAPP_DYN increases the yearly stock of population by a corresponding amount. New migrants socio-economic characteristics are simulated according current data available for Italy, accounting for the fact that this is not a random sample of the whole population. The entry age and gender is imputed consistently with the distribution by age class and gender of the official figures of

[14] It should be noticed, however, that the "real" flow of immigrants observed in the last decade has been consistently higher the ones projected by ISTAT (ISTAT, 2008b). Therefore, the use of official estimates may under-represent the stock of immigrants in the long-run. However, the model is sufficiently flexible in allowing the use of different scenarios.

Table 2: Singles, aged 18-34 living with at least one parents

	1998			***2003***			***2007***		
Class	***Males***	***Females***	***Total***	***Males***	***Females***	***Total***	***Males***	***Females***	***Total***
18-19	99,0	97,9	98,4	97,6	97,1	97,4	98.0	97.0	97.5
20-24	92,8	83,7	88,2	92,3	83,7	87,9	91.6	82.9	87.3
25-29	70,6	46,0	58,7	70,5	51,7	61,0	67.0	50.6	59.0
30-34	30,6	16,0	23,2	37,4	21,4	29,5	38.4	21.3	29.7
Total	*66,2*	*51,1*	*58,7*	*66,8*	*53,6*	*60,2*	*65.8*	*52.4*	*59.1*

Source: ISTAT (2007) "Multiscope surveys: "Aspetti della Vita quotidiana (2007)" and "Famiglia, Soggetti Sociali (2009)". Note: Mean value for 1998, 2003 and 2007 for 100 young in the same age class.

the legally registered immigrants as provided by ISTAT. Level of education, position with regards to the labour market and remaining socio-economic characteristics are randomly assigned according the ones observed among recent immigrants[15]. The future lives of the newly-migrants are then simulated on a year-by-year basis, accounting, where possible, immigrants' behavior not being the same as natives'.

4.4 The exit from household unit

The increasing delay of leaving the household of origin in order to establish an independent household is a well-established issue in Italy (Billari and Rosina, 2004): according to ISTAT, 59.1% of children aged 18-34 lived in 2007 with at least one parent (Table 2). By looking at the trend depicted in Table 2, it is worthwhile nothing that even if the percentage of not married people in the age band [18-34] living with at least one parent has been almost stable from 1998 to 2007, the share of those aged [30-34] increased considerably from 23.2% in 1998 to 29.5% in 2003, remaining almost stable afterwards. This is consistent with recent ISTAT figures that show an increasing share of employed children living with parents.

In modelling the exit from household unit in the long-run, CAPP_DYN uses the complement to 1 of the 2007-probabilities in table 2 in order to establish a steady state exit rule. Namely, each year a random number (u) is generated to each non-married sample member living with at least one parent. The generation of a new household is simulated if u is lower than the corresponding age-group specific probabilities.

[15] Data are taken from the sample of 2007 IT-SILC respondents who entered in the country between 2004 and 2006. In simulating this event, we are implicitly make a steady state assumption (i.e. socio-economic characteristics of future immigrants will be similar the ones observed in recent years). The model, however, excludes households' re-joining, assuming therefore, the immigrant being single at the entrance in the country.

4.5 Marriage

This module allows singles to get married each year, and the simulation of this event consists of three steps: first, the flow of yearly marriages is defined as 0.43% of total population [16]. Each year of simulation, once the number of marriages is determined, potential candidates (aged 16-60) are selected through a Monte Carlo process relying on probabilities of marriage conditional on gender and age provided by ISTAT multiscope survey "*Famiglie e soggetti sociali*" (ISTAT, 2007[17]). Candidates are then inserted in two distinct gender-specific groups and the following step aiming at matching those selected for the event. Literature points out the presence in Italy of *positive assortative mating* in marriages (Becker, 1973), according to which spouses select themselves in a non random way, being similar in terms of education (Rossetti, Tanda, 2000) and employment status (Del Boca et al., 2000). Those variables can be seen as proxy for socioeconomic status and cultural capital, and by the likelihood of meeting potential mates (Lewis and Oppenheimer, 2000). Marriage is then carried out by means of a matching procedure, based on the propensity score method (Rosenbaum and Rubin, 1983; Rubin and Thomas, 2000). We define the target group of potential matches as those in the marriage market of the opposite sex, who lives in the same area and of similar educational attainments, previous marital status, employment status and age.[18]. Each new household unit (including children from previous relationship, if any) is provided with a new Household IDentification number, which remains unvaried for the whole simulation period, if excluding possible divorce.

4.6 Divorce

Married couples are allowed to divorce with the following splitting up of the household into two different units headed by the two divorced individuals. As for the marriage module, the divorce simulation is carried out through three steps. Firstly, the yearly flow of divorces is defined as 0.3 % of the total number of married couple (ISTAT, 2007)[19]; secondly, couples which are likely to divorce are selected: as ISTAT finds a different incidence of divorce events both at geographical level and according to age, the selection process relies on

[16]The steady state hypothesis does not appear in this framework particularly strict: in fact, the marriage rate has not substantially modified in the last years. <http://www.ISTAT.it/salastampa/comunicati/non_calendario/20060424_00/indicatori_demografici.pdf>.

[17]ISTAT does not publish marriage probability by age and gender but reports the number of individuals getting married each year only. Starting from this information, cohort and periods effects apart, we obtain yearly marriage rates dividing the number of individual getting married by age and gender for the total number of marriages each year.

[18]Marriage age is generally lower for women than for man, having the former about three years more, according ISTAT figures. We assume that men of target ages are three years older than women.

[19]IT should be noticed, however, that the steady state hypothesis used in simulating divorce may be strict as statistics on this topic suggest a growing propensity to divorce in the last years.

estimated probabilities from ISTAT multiscope survey (ISTAT, 2009) data conditional on geographical area of residence and wife's age class. By means of a Monte Carlo process, the number of couples amounting to the yearly flow of divorces to be simulated is randomly selected amongst those with the highest predicted probabilities.[20] The splitting up of the household in two different units and the updating of marital status and household composition variables are then carried out.[21]

5 The disability module

The simulation of the disability condition is based on external information taken from the ISTAT Survey on public health and the use of the national health services (*Condizioni di salute e ricorso ai servizi sanitari*), which is carried out every five years on a sample of more than 100,000 individuals of all ages. The survey used in this version of CAPP_DYN was conducted in 2005. The survey collects (self-reported) information about individuals ability to carry out activities of daily living (ADLs), such as washing, eating and dressing and also instrumental activities (IADL) such as shopping and cleaning. There are 19 questions of this type, ranging from 0: *no difficulties*; 1: *with some difficulties*; 2: *only with the help of someone*. In line with the previous version of CAPP_DYN three levels of disability are considered, each of which depends on how many (I)ADLs limitations has been reported by the respondent. Estimated coefficients and cut-off parameters of an order probit are then used for generating individual's health status and disabilities profiles under two different hypotheses concerning the process generating the probability of being disabled: a pure ageing scenario where the probability of becoming disabled is fixed for each age, and an alternative scenario whereby the risk of being disabled is endogenously determined by changes in the socio-demographic characteristics of the future population. We refer to Baldini, Mazzaferro, and Morciano (2008) for a detailed description of this module.

6 The education and labour market module

Once the socio-demographic structure of the population and the disability status have been simulated, the model moves on to simulate decisions regarding the decision of acquiring education (for students) and the participation in the labour market. All individuals aged 16 are awarded the compulsory education level. At that age the module allows the definition of the highest educational attainment achieved by the individual, taking into account familiar

[20]Estimates from a probit model (estimated coefficients and variance) are used in ranking candidates.

[21]Eventual children will belong to mother's household unit. According to ISTAT in 85% of cases underage children will be fostered to the mother.

background. A higher educational level delays the entry into the labour market up to the achievement of the imputed educational level. The end of schooling is followed by the entry into the labour market.

The in and out flows into/from the labour force and employment transitions are then simulated. Stock of active population is divided in two sub-groups: public and private employees and self employed. Both can work part time or full time. A share of population is employed with atypical and fixed term contracts. Finally, for those employed, a sub-module allows the determination of earnings, taking into account growth in productivity.

6.1 Education

The accumulation of human capital represents a critical element when simulating the economic condition of a population. Better educated people have higher employment probability, high level of earning and steeper age-earning profile, *ceteris paribus*. The fact that family background plays a crucial role in determining child's education has been broadly recognized (Haveman and Wolfe, 1995; Ermisch and Francesconi, 2001). For Italy, Mocetti (2007) and Checchi, Fiorio, and Leonardi (2008) found a strong degree of intergenerational persistence in educational attainment.

On the basis of the above mentioned evidences, we simulate educational attainments as follow. All individuals aged 16 are deemed to have completed their compulsory education. At that age, we simulate the probability of individual i continuing full-time education using estimates of an ordered probit model where the educational level attained by i depends on a set of observables including family background indicators,and taking into account as far as possible - the presence of cohort effects.

Formally, defining y_i as the observed and achieved educational level, and $\tilde{y}_i$ the corresponding latent variable, we model the alternatives in an ordinal form which implies the following general structure:

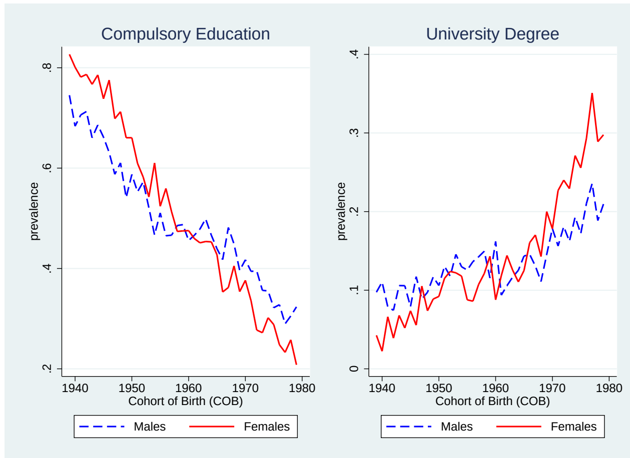
$$\begin{gathered} y_i = j \qquad iff\ c_{j-1} < \tilde{y}_i < c_j, \quad r = 1, \ldots, J \\ \tilde{y}_i = \beta' x_i + \varepsilon_i \end{gathered} \tag{4}$$

where J is the number of categories for y_i :*1* compulsory education, :*2* secondary school, :*3* university education; X_i is the vector of observables which include family background characteristics; c_j are threshold parameters estimated jointly to the column vector of β coefficients.

Data are taken from the 2005 wave of IT-SILC. It collected rare[22] information on the ed-

[22] More often, a dataset which contains the educational achievements of both child and parents is not available. The absence of appropriate datasets is generally overcome by adopting the two-sample two-stage least

Figure 3: Percentage of those with compulsory education (*left*) and university degree (*right*) by cohort of birth



ucation attainments of the parents when respondent was aged 15, allowing the estimation of the model comprising equation (4). Figure 3 shows the percentage of those with compulsory education and university degree by cohort of birth as observed in the raw data. It can be seen a clear trend toward a dramatically increase of level of education by Cohort of Birth (CoB). Females born before the sixties had a declining gap in term of level of education compared with man whereas the trend is reversed for youngest cohorts with an increasing and reversed.

Given our purpose of making projections for the future, we restrict the sample to those born after the sixties, estimating model comprising equation (4) over a sample of 14,606 non-missing respondents born between 1961 and 1979[23]. Regression results obtained are reported in Table 3. We account for different trends in CoB between males and females adding interaction terms in the vector of x. The first column shows estimated coefficients, while columns 2-4 display marginal effects for every single value of the dependent variable. Estimates of equation (4) suggest that educational attainments appear to be strongly dependent from parents' educational level. There is a clear increasing trend for both males and females born after 1971. For females, however, the positive trend started earlier, since the coefficient associated with the interaction term with CoB [1966-1970] is positive and significant (at 0.05). Columns 2-4 of Table 3 present the marginal effects for every single value of the dependent variable. Since all regressors are in the form of dummy variables,

squares method (Angrist and Krueger, 1992; Arellano and Meghir, 1992).

[23]The sample has been truncated of those born after 1979 in avoiding sample selection biases due to the inclusion of cohorts of whom -at the time the interview took place- would be still engaged in acquiring education.

Table 3: Ordered probit of educational level

	Coefficients	y=Pr(j==1)	y=Pr(j==2)	y=Pr(j==3)
High School Educ. Mother (d)	0.541***	-0.179	0.024	0.155
University Degree Mother (d)	0.703***	-0.213	-0.008	0.221
High School Educ. Father (d)	0.691***	-0.223	0.019	0.204
University Degree Father (d)	1.218***	-0.307	-0.112	0.418
Mother in work (d)	0.100***	-0.037	0.012	0.025
Father in work (d)	0.084**	-0.031	0.012	0.019
Woman (d)	0.026	-0.010	0.003	0.006
CoB [1966-1970] (d)	0.044	-0.016	0.006	0.011
CoB [1971-...] (d)	0.187***	-0.069	0.023	0.045
Women*CoB [1966-1970] (d)	0.130*	-0.047	0.014	0.032
Women*CoB [1971-...] (d)	0.218***	-0.079	0.023	0.055
c(1)	0.109***			
c(2)	1.512***			
Predicted probabilities (mean)		0.347	0.497	0.156

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Reference category: Child (male) born before between 1961 and 1965, with mother/father with compulsory education and not at work when child aged 15.

the marginal effect on category j of y for a dummy variable x is $Pr\,(y = j)$ evaluated at *x=1* and the mean of the remaining regressors minus $Pr\,(y = j)$ evaluated at $x = 0$ and the mean of the remaining regressors. The chance to enroll to tertiary education is *ceteris paribus* 22% higher for those with a mother with a university degree. If both parents have a university degree, then $Pr\,(y = 3)$ is about 63.9% (0.221+0.418) higher *ceteris paribus.* Conversely, the probability of the same child to stop to compulsory schooling $Pr\,(y = 1)$ is being 48.6% lower than the one obtained by the reference individual,*ceteris paribus.* Results provide strong support on the evidence for Italy of high intergenerational persistence in educational attainment. Cohort dummies suggest a positive trend in schooling for younger generations. *Ceteris paribus* an male born after 1971 has a higher probability (+4.5%) to achieve a university degree than an individual born in the period 1961-65. For a female this figure is even stronger.

Estimated coefficients and the cut-off parameters in Table 3 are then used in CAPP_DYN for predicting what level of education j an individuals aged 16 will reach. Predicetd probabilities of the j-categories of y are calculated as follow:

$$pr\left(y_i = 1\right) = \int_0^{c_1} y_i^* dy = \Phi\left[\left(c_1 - \beta' x_i\right)\right]$$

$$pr\left(y_i = 2\right) = \int_{c_1}^{c_2} y_i^* dy = \Phi\left[\left(c_2 - \beta' x_i\right)\right] - pr\left(y_i = 1\right)$$

$$pr\left(y_i = 3\right) = \int_{c_2}^{1} y_i^* dy = 1 - \Phi\left[\beta' x_i - c_2\right]$$

where Φ is the cumulative standard normal and c (with $c_0 < c_1 < c_4$) is the vector of estimated cut points. The simulation of the individual educational attainment is finally simulated comparing the vector of cumulative J-probabilities with a random number drawn from an uniform distribution with support [0,1] [24]. If the education attainment of an individual is *y=1* then the year after (when she/he is 16 years old) will entry in the labour market. For those with *y=2* their entry in the labour market will be at age 18. Those with *y=3* are splitted into two categories: 30% of enrolled students terminate at the age of 21 (having a three-year degree), while the remaining will achieve the five-year degree, entering in the labour market at the age of 23.

6.2 Entry and transitions in the labour market

A higher educational level delays entry into the labour market until individuals achieve the simulated educational attainment. Occupational attainments and sector are assumed to be time-invariant over the whole simulation period for each individual, whereas employment status are allowed to change over time.

At each point in time all sample members, excluding pensioners and students, can be classified according to following $J-$statuses:

- full time worker (at least 31 working hours);
- part-time worker (less than 31 working hours);
- unemployed;
- not in work force (unemployed individuals not looking for a job).

The first task is to assign one of the above status to whom entry for the first time in the job market. Transition probabilities from education to the job market are estimated using a sample of IT-SILC 2007 respondents that completed their studies between 2002 and 2006[25]. The probability that ex-student i being in one of the four possible statuses of J in time t is modelled as follow:

[24] The same procedure is applied to the students over 15 of the base year, in order to define the human capital level they are likely to reach. The imputed value is constant over all the simulation period.

[25] The selection rule we applied allows to have a sample composed by 1912 observations.

Table 4: Multinomial Logit of entry in the labour market *(initial condition)*

	Coeffs.			
	FT worker	PT worker	Unemployed	Not in work force
Women	-0.769***	0.348	-0.570**	.
University Degree	1.365***	1.021**	0.411	.
Diploma	1.485***	1.455***	0.872***	.
Predicted probabilities	0.518	0.0848	0.238	0.0956

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Reference category: Male with compulsory education and not in work force (N=1912).

$$Prob\left(J_t = j|x_{it}\right) = \frac{\exp\left(\beta_j' x_{it}\right)}{1 + \sum_{j=1}^{J} \exp\left(\beta_j' x_{it}\right)} \tag{5}$$

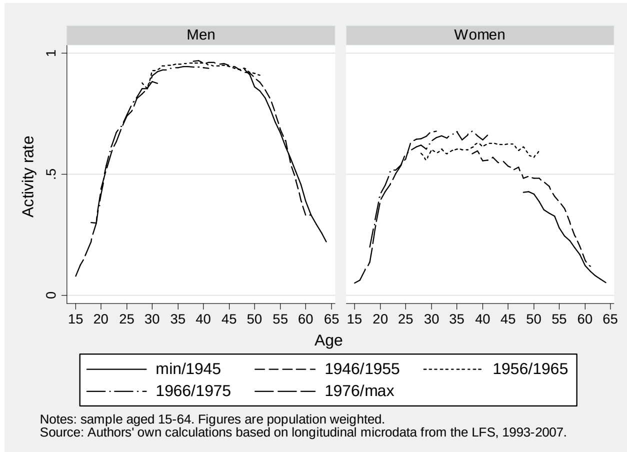
Table 4 presents estimated coefficients of the multinomial logit model in equation (5). The higher the level of educational attainment, the lower the probability of being not in work force (reference category) or unemployed. Males are more likely to be employed than female, although the associated coefficient for being part-time (PT) worker is positive but not significant different from zero. Overall, the probabilities for ex-students of being FT (PT) worker is 58.1% (8.5%). About 1 ex-student over 3 is unemployed or not in work force according our estimates. These figures, used to simulate the initial position (at time *t*) in regards to the labour market of those who left full-time education in *t-1* are quite similar the official ones recently published by ISTAT.

We turn now to present the econom(etr)ic framework used in modelling the labour market dynamics (i.e. considering transitions from the occupational state at the beginning of the period (year *t*), and the end of the period (*t+1*)). A detailed description of this module together with a comprehensive analysis of the recent trends in the Italian labour market can be found in Flisi and Morciano (2011).

On the whole, there have been remarkable improvements in activity and employment rates in the last 15 years in some segments of the Italian labour market: age being equal, subsequent cohorts of women show systematically higher activity and employment rates (Figure 4), mainly due to an increase of part-time work[26]. However, such improvements are not enough to approach the targets set by the Lisbon Strategy (EU - European Commission, 2008).

[26]around 1/4 of employed women have this work arrangement in 2007, 5 times the share of male part-time workers.

Figure 4: Activity rates by gender and cohort



Source: Flisi and Morciano (2011) LFS data 1993-2007.

Table 5 shows the transition matrices from the occupational state from t to $t+1$, for the whole period, disaggregated by gender. The proportions displayed on the main diagonals point in the direction of a significant level of persistence in the original state, especially for those employed full-time (96% and 91% for men and women, respectively) and for woman in state of inactivity (89%). Those who were unemployed in t show a relatively higher mobility: among men, 30% have a job at time $t+1$, compared with 20% among women. These figures are clearly just mean trend indicators. Is well know that labour market transitions (or persistence) are influenced by a number of personal characteristics, which would not been taken into account if the transition matrix in use would have the elements in Table 5.

In order to account for trends mentioned above and for individual heterogeneity we follow the econometric approach used -among others- by Bellmann, Estrin, Lehmann, and Wadsworth (1995) and for the Italian case by Chies, Riccardo, and Staffolani (1998). In these models, and in keeping with other DMM, is assumed that employment decisions are fully determined by features of the supply side of the labour market, and are thus independent of demand-side factors. The dependent variable is the work state J at time $t+1$, and the base outcome for the multinomial logit models is full-time employment. Formally, the probability that individual i being in one of the four possible statuses of J in time t is modelled as follow:

Table 5: Labour market transition matrix from t to $t+1$ by gender

		Year t+1			
		Employed FT	Employed PT	Unemployed	Inactive
		Men			
Year t	Employed FT	96.42	1.12	1.42	1.05
	Employed PT	40.08	48.67	6.22	5.02
	Unemployed	26.03	3.89	52.60	17.48
	Inactive	23.56	3.55	26.38	46.51
		Women			
Year t	Employed FT	91.00	4.13	1.60	3.27
	Employed PT	19.08	69.48	3.32	8.12
	Unemployed	13.33	6.62	47.55	32.50
	Inactive	3.31	1.96	5.38	89.35

Notes: The sample includes 554,151 individuals. All figures are population weighted.
Source: Authors' own calculations based on longitudinal microdata from the LFS, 1993-2007

Source: Flisi and Morciano (2011)

$$Prob\left(J_{t+1}=j|j_t,x_{it}\right)=\frac{\exp\left(\beta_j' x_{it}\right)}{1+\sum_{j=1}^{4}\exp\left(\beta_j' x_{it}\right)} \tag{6}$$

where j is one of the four feasible statuses, x represents the covariates vector and β_j the vector of j-specific associated coefficients. Data are taken from the Italian Labour Force Survey data (herein after LFS[27]) covering a long period of 15 years (1993-2007). As covariates we include a lag of the dependent variable which takes the form of dummy variables for the possible working states at time t, in order to facilitate the presentation and discussion of results[28].

Estimates obtained over a (weighted) sample of 554,151 individuals are reported in Table 6 and Table 7 for females and males, respectively, together with the relative marginal effects evaluated at the sample means of the explanatory variables. The benchmark state is full-time employment, so that the parameters in columns 1-3 in the Tables have to be read in relation to that base outcome[29].

[27] *"Rilevazione Trimestrale sulle Forze di Lavoro"* (ISTAT,various years).

[28] It is worth noting that, as pointed out by (Chies, Riccardo, and Staffolani, 1998), the choice of the control variables is not meant to describe the behavior of individuals (as of course it is hard to believe that all transitions are due to the individual's decision), but rather to investigate the determinants of mobility between different labour market states.

[29] It is reasonable to evaluate the parameters with full-time employment as reference state, as it is the most

Table 6: Multinomial logit estimates of labour market transitions - Women

Work state at time $t+1$	Coefficients						Marginal effects							
	Part-time employment		Unemployment		Inactivity		Full-time employment		Part-time employment		Unemployment		Inactivity	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Whether in PT employment at time *t*	4.287 ***	(0.026)	2.2792 ***	(0.052)	2.4406 ***	(0.039)	-0.4556 ***	(0.003)	0.4380 ***	(0.007)	-0.0065 **	(0.003)	0.0241 ***	(0.009)
Whether unemployed at time *t*	2.5326 ***	(0.052)	4.9882 ***	(0.061)	4.0041 ***	(0.043)	-0.4954 ***	(0.003)	-0.0534 ***	(0.002)	0.2515 ***	(0.012)	0.2974 ***	(0.013)
Whether inactive at time *t*	2.5817 ***	(0.045)	4.4120 ***	(0.060)	5.8996 ***	(0.035)	-0.8148 ***	(0.002)	-0.0338 ***	(0.002)	0.0484 ***	(0.003)	0.8002 ***	(0.003)
Upper secondary	-0.2221 ***	(0.024)	-0.4215 ***	(0.027)	-0.7105 ***	(0.023)	0.1428 ***	(0.005)	0.0088 ***	(0.002)	-0.0083 ***	(0.002)	-0.1433 ***	(0.005)
Tertiary	-0.3223 ***	(0.040)	-0.8404 ***	(0.048)	-1.2640 ***	(0.047)	0.2388 ***	(0.008)	0.0134 ***	(0.004)	-0.0253 ***	(0.002)	-0.2269 ***	(0.007)
Age	0.0624 ***	(0.009)	0.0415 ***	(0.009)	-0.0495 ***	(0.007)	0.0042 ***	(0.002)	0.0071 ***	(0.001)	0.0039 ***	(0.001)	-0.0153 ***	(0.002)
Age^2	-0.0009 ***	(0.000)	-0.0011 ***	(0.000)	0.0009 ***	(0.000)	-0.0001 ***	(0.000)	-0.0001 ***	(0.000)	-0.0001 ***	(0.000)	0.0003 ***	(0.000)
Centre	-0.0460	(0.029)	0.3162 ***	(0.036)	0.2277 ***	(0.028)	-0.0477 ***	(0.006)	-0.0149 ***	(0.002)	0.0167 ***	(0.003)	0.0459 ***	(0.006)
South	-0.2502 ***	(0.027)	0.8846 ***	(0.028)	0.7151 ***	(0.023)	-0.1411 ***	(0.005)	-0.0534 ***	(0.002)	0.0449 ***	(0.002)	0.1496 ***	(0.005)
Married/cohabiting	0.3490 ***	(0.027)	-0.1677 ***	(0.029)	0.8628 ***	(0.026)	-0.1477 ***	(0.005)	0.0030	(0.002)	-0.0411 ***	(0.002)	0.1858 ***	(0.005)
Public sector	-0.2096 ***	(0.027)	-0.4458 ***	(0.052)	-0.4851 ***	(0.040)	0.1062 ***	(0.007)	0.0016	(0.003)	-0.0158 ***	(0.003)	-0.0920 ***	(0.009)
Employee	0.1110 ***	(0.033)	0.2834 ***	(0.062)	-0.2909 ***	(0.038)	0.0334 ***	(0.007)	0.0187 ***	(0.003)	0.0287 ***	(0.005)	-0.0808 ***	(0.009)
1994	-0.1029 *	(0.062)	-0.0392	(0.059)	-0.0608	(0.049)	0.0161	(0.011)	-0.0064	(0.005)	-0.0003	(0.004)	-0.0094	(0.010)
1995	-0.0775	(0.060)	-0.0194	(0.058)	-0.0461	(0.048)	0.0118	(0.011)	-0.0049	(0.005)	0.0006	(0.003)	-0.0074	(0.010)
1996	-0.0487	(0.059)	0.0370	(0.056)	-0.0677	(0.047)	0.0122	(0.010)	-0.0021	(0.005)	0.0051	(0.004)	-0.0152	(0.009)
1997	0.0059	(0.059)	0.0364	(0.057)	-0.0956 **	(0.047)	0.0144	(0.011)	0.0038	(0.005)	0.0055	(0.004)	-0.0237 **	(0.010)
1998	0.1272 **	(0.058)	0.0619	(0.057)	-0.0963 **	(0.048)	0.0078	(0.011)	0.0152 ***	(0.005)	0.0063 *	(0.004)	-0.0293 ***	(0.009)
1999	0.1416 **	(0.058)	0.0402	(0.057)	-0.0840 *	(0.048)	0.0059	(0.011)	0.0163 ***	(0.005)	0.0042	(0.004)	-0.0264 ***	(0.010)
2000	0.1636 ***	(0.059)	-0.0953	(0.059)	-0.1072 **	(0.049)	0.0131	(0.011)	0.0207 ***	(0.006)	-0.0049	(0.003)	-0.0289 ***	(0.010)
2001	0.1327 **	(0.059)	0.0061	(0.058)	-0.0740	(0.049)	0.0059	(0.011)	0.0153 ***	(0.005)	0.0015	(0.004)	-0.0227 **	(0.010)
2002	0.2234 ***	(0.057)	-0.0175	(0.058)	-0.1023 **	(0.048)	0.0065	(0.010)	0.0260 ***	(0.006)	-0.0002	(0.004)	-0.0324 ***	(0.010)
2004	0.6166 ***	(0.061)	-0.0010	(0.072)	0.2426 ***	(0.056)	-0.0698 ***	(0.012)	0.0536 ***	(0.007)	-0.0123 ***	(0.004)	0.0285 **	(0.012)
2005	0.6657 ***	(0.060)	0.0708	(0.073)	0.1712 ***	(0.059)	-0.0636 ***	(0.012)	0.0634 ***	(0.007)	-0.0062	(0.004)	0.0065	(0.012)
2006	0.6821 ***	(0.062)	-0.2456 ***	(0.080)	0.2285 ***	(0.063)	-0.0658 ***	(0.013)	0.0652 ***	(0.008)	-0.0264 ***	(0.004)	0.0269 **	(0.014)
2007	0.7901 ***	(0.060)	0.0515	(0.075)	0.0770	(0.061)	-0.0572 ***	(0.012)	0.0865 ***	(0.008)	-0.0064	(0.004)	-0.0228 *	(0.012)
Constant	-4.3367 ***	(0.169)	-4.0870 ***	(0.171)	-2.9159 ***	(0.148)								
Observations			283,062											
Pseudo R^2			0.568											
Predicted probability (at sample means)							0.4403		0.0985		0.0771		0.3840	

Notes: the reference individual is a single, self-employed woman working full-time in the private sector, with compulsory education, living in Northern Italy. Robust standard errors are in parentheses. Estimates are weighted using longitudinal weights from LFS. Marginal effects are calculated at the sample means of the explanatory variables. * denotes statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.
Source: Authors' own calculations based on longitudinal microdata from the LFS, 1993-2007

Source: Flisi and Morciano (2011)

Table 7: Multinomial logit estimates of labour market transitions - Men

Work state at time *t+1*	Coefficients						Marginal effects							
	Part-time employment		Unemployment		Inactivity		Full-time employment		Part-time employment		Unemployment		Inactivity	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
Whether in PT employment at time *t*	4.5332 ***	(0.038)	2.2133 ***	(0.065)	2.2892 ***	(0.071)	-0.5864 ***	(0.007)	0.4994 ***	(0.008)	0.0478 ***	(0.004)	0.0391 ***	(0.003)
Whether unemployed at time *t*	2.4102 ***	(0.061)	4.5954 ***	(0.046)	3.8171 ***	(0.051)	-0.6498 ***	(0.007)	0.0358 ***	(0.003)	0.4567 ***	(0.009)	0.1573 ***	(0.006)
Whether inactive at time *t*	2.369 ***	(0.072)	4.0436 ***	(0.051)	4.8026 ***	(0.051)	-0.6871 ***	(0.007)	0.0294 ***	(0.003)	0.255 ***	(0.009)	0.4027 ***	(0.011)
Upper secondary	-0.081 **	(0.035)	-0.2979 ***	(0.027)	-0.3726 ***	(0.031)	0.0117 ***	(0.001)	-0.0011 **	(0.001)	-0.0055 ***	(0.001)	-0.0051 ***	(0.000)
Tertiary	-0.1247 **	(0.059)	-0.6985 ***	(0.058)	-0.8087 ***	(0.066)	0.0208 ***	(0.001)	-0.0016 *	(0.001)	-0.0105 ***	(0.001)	-0.0087 ***	(0.001)
Age	-0.0515 ***	(0.010)	-0.0544 ***	(0.007)	-0.0956 ***	(0.008)	0.0032 ***	(0.000)	-0.0008 ***	(0.000)	-0.0010 ***	(0.000)	-0.0014 ***	(0.000)
Age^2	0.0007 ***	(0.000)	0.0005 ***	(0.000)	0.0014 ***	(0.000)	0.0000 ***	(0.000)	0.0000 ***	(0.000)	0.0000 ***	(0.000)	0.0000 ***	(0.000)
Centre	0.1738 ***	(0.048)	0.4298 ***	(0.041)	0.3754 ***	(0.047)	-0.0180 ***	(0.002)	0.0026 ***	(0.001)	0.0094 ***	(0.001)	0.0059 ***	(0.001)
South	0.4345 ***	(0.036)	1.1447 ***	(0.031)	1.0443 ***	(0.034)	-0.0508 ***	(0.001)	0.0065 ***	(0.001)	0.0268 ***	(0.001)	0.0175 ***	(0.001)
Married/cohabiting	-0.3265 ***	(0.041)	-0.5916 ***	(0.031)	-0.7652 ***	(0.035)	0.0295 ***	(0.001)	-0.0050 ***	(0.001)	-0.0123 ***	(0.001)	-0.0123 ***	(0.001)
Public sector	0.2846 ***	(0.043)	-0.7980 ***	(0.063)	-0.6269 ***	(0.072)	0.0147 ***	(0.001)	0.0053 ***	(0.001)	-0.0125 ***	(0.001)	-0.0075 ***	(0.001)
Employee	-0.0752 *	(0.042)	0.4130 ***	(0.047)	0.1964 ***	(0.052)	-0.0091 ***	(0.001)	-0.0014 **	(0.001)	0.0078 ***	(0.001)	0.0027 ***	(0.001)
1994	-0.0906	(0.088)	-0.1395 **	(0.058)	-0.1944 ***	(0.070)	0.0064 ***	(0.002)	-0.0013	(0.001)	-0.0025 **	(0.001)	-0.0026 ***	(0.001)
1995	-0.1495 *	(0.086)	-0.1266 **	(0.057)	-0.0738	(0.065)	0.0055 ***	(0.002)	-0.0022 *	(0.001)	-0.0023 **	(0.001)	-0.0010	(0.001)
1996	-0.0672	(0.083)	-0.0800	(0.056)	-0.1330 **	(0.065)	0.0043 **	(0.002)	-0.0010	(0.001)	-0.0015	(0.001)	-0.0018 **	(0.001)
1997	0.0451	(0.082)	-0.0923 *	(0.056)	-0.2199 ***	(0.066)	0.0038 *	(0.002)	0.0008	(0.001)	-0.0017 *	(0.001)	-0.0029 ***	(0.001)
1998	-0.0763	(0.083)	-0.1259 **	(0.055)	-0.1710 ***	(0.066)	0.0057 ***	(0.002)	-0.0011	(0.001)	-0.0023 **	(0.001)	-0.0023 ***	(0.001)
1999	0.1342 *	(0.080)	-0.1510 ***	(0.055)	-0.1047	(0.065)	0.0019	(0.002)	0.0023	(0.001)	-0.0028 ***	(0.001)	-0.0015 *	(0.001)
2000	0.0257	(0.082)	-0.2121 ***	(0.056)	-0.0865	(0.066)	0.0045 **	(0.002)	0.0005	(0.001)	-0.0038 ***	(0.001)	-0.0012	(0.001)
2001	0.0458	(0.082)	-0.1560 ***	(0.057)	-0.1147 *	(0.067)	0.0036 *	(0.002)	0.0008	(0.001)	-0.0029 ***	(0.001)	-0.0016 *	(0.001)
2002	-0.0022	(0.082)	-0.2495 ***	(0.057)	-0.1945 ***	(0.067)	0.0069 ***	(0.002)	0.0001	(0.001)	-0.0044 ***	(0.001)	-0.0026 ***	(0.001)
2004	0.2459 ***	(0.091)	-0.2505 ***	(0.069)	0.3199 ***	(0.074)	-0.0051 *	(0.003)	0.0043 **	(0.002)	-0.0046 ***	(0.001)	0.0054 ***	(0.001)
2005	0.2915 ***	(0.087)	-0.3779 ***	(0.071)	0.2632 ***	(0.073)	-0.0031	(0.003)	0.0053 ***	(0.002)	-0.0065 ***	(0.001)	0.0043 ***	(0.001)
2006	0.2711 ***	(0.086)	-0.4430 ***	(0.080)	0.4043 ***	(0.074)	-0.0045	(0.003)	0.0048 ***	(0.002)	-0.0075 ***	(0.001)	0.0071 ***	(0.002)
2007	0.3389 ***	(0.088)	-0.3834 ***	(0.074)	0.4031 ***	(0.076)	-0.0066 **	(0.003)	0.0062 ***	(0.002)	-0.0067 ***	(0.001)	0.0070 ***	(0.002)
Constant	-3.6564 ***	(0.198)	-2.9990 ***	(0.143)	-2.9948 ***	(0.152)								
Observations			271,089											
Pseudo R^2			0.412											
Predicted probability (at sample means)							0.9489		0.0161		0.0201		0.0148	

Notes: the reference individual is a single, self-employed man working full-time in the private sector, with compulsory education, living in Northern Italy. Robust standard errors are in parentheses. Estimates are weighted using longitudinal weights from LFS. Marginal effects are calculated at the sample means of the explanatory variables. * denotes statistical significance at the 10% level, ** at the 5% level and *** at the 1% level.
Source: Authors' own calculations based on longitudinal microdata from the LFS, 1993-2007

Source: Flisi and Morciano (2011)

For both males and females, the high level of persistence in the original state is confirmed by the dummies relative to the three alternative work states at time *t*. These dummies show significantly higher estimated parameters when the state at time *t+1* is the same as in the previous year. The higher the level of educational, the lower the probability of spells of unemployment and/or of movements out of work. Older males experience lower probability of transitions. Stated differently, younger people are more prone to change labour market state than their older counterparts, *ceteris paribus*.[30] Age does not necessarily appear to keep "worse" labour market outcomes at bay, as happens for men; on the one hand, an older woman seems to be less likely to exit the labour force, and more likely to be still in full-time employment one year later; however, females have a higher propensity to be in part-time employment or unemployed. This different behaviour when compared to men can be explained by the fact that for women age may not be so closely related to work experience, as female employment histories tend to be much more fragmented. The propensity to leave full-time employment for another state varies significantly across regions being transitions (in particular the ones from a working condition to a non-working one) more likely to occurs in the South and in the Central Italy. It should be noted, however, that residence in these regions also appears to imply a lower propensity to work part-time; this may be due to the wider diffusion of this work arrangement in the North than in the rest of Italy. As expected, marital status has a very different impact for women than for men. For men, being married appears to increase the propensity to be still in full-time employment at time *t+1* and it reduces the probability to be outside the labour market. For women, it diminishes the chance of still being in full-time employment one year later, but also those of being unemployed; on the other hand, the positive marginal effect in column 7 shows that married females are more likely to exit the labour force; therefore, other things being equal, being married appears to substantially reduce female attachment to the labour market, *ceteris paribus*. Working in the public sector rather than in the private is associated with a higher chance of transition to part-time employment (only for women), and to a lower chance of being out of work. When compared to a situation of self-employment, being an employee carries a lower chance to drop out of the labour market, but not of being unemployed or in part-time work instead of full-time. Finally, as expected, yearly dummy variables depict a clearly trend towards an increase in working opportunities over time, in particular for women.

Estimates mentioned above allow to calculate the probability vector for each individual in each of the simulated year. A Monte Carlo process enables the simulation of the individual's job status in period *t*.[31]

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common work condition in our sample: 86% of the men are employed full-time at time *t*. We do not find a comparable prevalence of FT work among women: only 42% of female individuals find themselves in this occupational state, yet this is still the most frequent outcome.

[30] Age is highly correlated with working experience, in particular for (older) man workers who have a fairly continuous employment history.

[31] Consistently with previous works (Creedy et al, 1993; Disney and Emmerson, 2005), mobility between

6.3 Earnings

Once a position in the labour force is simulated, the yearly-earning is generated for workers. For a detailed description of the econom(etr)ic framework in use we refer to Ciani and Morciano (2011). The classical theoretical guide is the Mincer earnings function, where the logarithm of earnings y is a linear function of years of education t and of experience r (Cahuc and Zylberberg, 2004, p. 87) plus a set of observable characteristics. Defining $\ln y_{it}$ the logarithm of the monthly earning of individual i at time t, the model can be written as follow:

$$\ln y_{it} = z_{it}\beta + \varepsilon_{it} \tag{7}$$

where z is a $K \times 1$ vector containing r_{it},r_{it}^2 and x_i, with K=J+3. β is the $K \times 1$ vector of parameters associated with z and ε_{it} is a random disturbance term. Years of experience is proxied by number of years in which the individual has paid social contributions. In allowing different shapes of the earning equation, we estimate the model in (7) among the following seven groups:[32]

1. Men, not graduated, employees;
2. Men, graduated, employees;
3. Women, not graduated, employees;
4. Women, graduated, employees;
5. Graduated self-employed[33];
6. Men, not graduated, self-employed;
7. Women, not graduated, self-employed.

We also added a vector of J regressors x to the basic model, as we expect them to have some effect on the earnings level: age and age squared; immigrant status; geographical area of residence; sector of employment; part-time or full-time job. In groups of non-graduated workers we also included a dummy indicating whether or not the individual completed secondary education. For self-employed, we control for a binary variable assuming value one if they have atypical contracts. Lastly, we add a dummy for females for the graduated self-employed[34]. Furthermore, we added some interactions where required to improve the

industries, occupations and sectors are not currently modelled.

[32] A similar procedure is used by the Australian Microsimulation model NATSEM (Bæ kgaard, 2002, p. 39).

[33] We did not split the group of graduated self-employed by gender in order to maintain a larger number of observations. See Ciani and Morciano (2011).

[34] The gain in adding these variables is the increased amount of log-earnings variance explained by our model, even if we lose the correspondence with the theoretical Mincer equation.

specification of the conditional mean. In order to choose which to include, we decided to proceed by adding interactions between the year of contributions on the one side and geographical and secondary education dummies on the other.[35]

The model in equation 7 can be estimated using OLS, assuming linearity between log earning and its determinants, in line with the method used in many DMM. Parameters of equation 7 can be used to predict the deterministic component of the individual earnings in every year of the simulation. However individual income differs because of the presence of unobserved individual effects and a yearly component which can be thought of as the increase in productivity distributed to all workers in each simulation period. However, equation 7 does not allow for serial correlation due both to individual unobserved heterogeneity and to an autoregressive transitory component. Following Lillard and Willis (1978) and the application of Borella and Coda Moscarola (2006) for Italy we model earnings residuals including an individual effect plus a first-order autoregressive component:

$$\begin{array}{rlr} \varepsilon_{it} = \mu_i + \xi_{it} & & \mu_i \sim iid\left(0, \sigma_\mu^2\right) \\ \xi_{it} = \rho \xi_{it-1} + w_{it}; & w_{it} \sim iid\left(0, \sigma_w^2\right); & |\rho| < 1 \end{array} \tag{8}$$

where for β, σ_μ^2 and σ_w^2 strictly exogeneity is assumed, so that at each period t the time-varying error component is independent from the vector of covariates at all time periods. Assuming that the individual effects μ_i are *iid* and independent from the regressors z_{it} in equation 7, the model comprising equations 7 and 8 can be estimated using random effects[36]. Estimates of equation 7 using the 2007 IT-SILC cross-section and the ones comprising model in equations 7 and 8 estimated on the first four rotational panels of IT-SILC (2004-2007, 2005-2008, 2006-2008,2007-2008) are presented in Table 8 and Table 9, respectively.

From 8 we found that geographical differences are highlighted by a positive North dummy coefficient, while the South dummy is usually negative. Private sector employees tend to have lower gross earnings. Part-time workers show sensible lower earnings, even if the difference is lower among self-employed. The coefficient on the immigrant dummy is negative and quite large, as it might have been expected. Coefficients on age and years of social contributions are always positive, apart from the small and not significant coefficient for men, not graduated, self-employed. There seems to be decreasing returns on age or experience, as the quadratic term is generally negative. Among not-graduated employees, the interaction term between social contribution and secondary education is positive and significant, as well as the interaction with the North dummy, showing higher returns on

[35]The original Mincer model predicts that "log-earnings experience profiles are parallel across schooling levels" (Heckman, Lochner, & Todd, 2003, p. 8). However, Heckman et al. (2003) strongly rejected this assumption with US data.

[36]See Ciani and Morciano (2011) for a discussion of the pros and cons in using random effects models in this context.

experience for these groups. Lastly, the atypical dummy is negative and significantly different from zero only among men, not graduated, self-employed. Results are in line with expectations and previous studies.[37].

Results of the longitudinal model are reported in Table 9.[38] The dummy north is generally smaller with respect to OLS, while south, secondary and female are similar. The coefficient on age and age squared is larger for all groups of employees. However, it is likely to include some of the effect of contributions, because the coefficient on its proxy years spent in paid work is smaller than what we observe for contributions in the cross-section. Among self-employed, the largest difference is observed for not-graduated men, because we find coefficients on age and age squared, which are respectively positive and negative. The most significant finding is that the dummy for part-time exhibits smaller coefficients in all groups, in particular among employees. If we interpret it in terms of elasticities, the coefficient seems indeed quite small from the economic perspective. One possible reason is that the variable part-time does not satisfy the strict exogeneity restriction.

The projections of individual annual earning in CAPP_DYN make use of estimates of the model comprising equations 7 and 8, following Pudney Pudney (1992). According (8), the autoregressive component implies that:

$$cov(\xi_{it}, \xi_{it-k}|z_{it}) = \rho^k \sigma_\xi^2 \tag{9}$$

where $z_{it} = \left(z_{i0}^{'}, z_{i1}^{'}, \ldots, z_{iT}^{'}\right)^{'}$. It is interesting to note that, in the population, we can identify the mean of individual's log-earnings y_{is} in period s conditional on log-earnings at a different period t, y_{it} , and on the set of covariates at both time periods z_{it} and z_{is}. Assuming normality of both components of the error, and independence among them, the conditional expectation of y_{is}, is:

$$E(y_{is}|y_{it}, z_{it}, z_{is}) = z_{is}\beta + \delta\left(s, t\right)\left(y_{it} - z_{it}\beta\right) \tag{10}$$

The first term can be interpreted as the deterministic part computed using coefficients in Table 9 or alternatively using coefficients obtained from the cross-sectional models (Table 9) by the vector of updated characteristics z_{is} whereas the second term is the product between the term $(y_{it} - z_{it}\beta)$, which is equal to the composite error term ε_{it} and a weighting factor:

[37] One exception is that, in contrast with Brugiavini and Peracchi (2004), we depicted an increase in earnings with age even for individuals aged 50-64, *ceteris paribus.*

[38] Note that the results are not directly comparable with Table 8 because in the set of regressors we include variables that are missing (private, atypical). Moreover, contributions is proxied by years spent in paid work.

Table 8: log-OLS cross-section estimates, Euros 2006

	Men, not graduated, employees	Women, not graduated, employees	Men, graduated, employees	Women, graduated, employees	Graduated, self-employed	Men, not graduated, self-employed	Women, not graduated, self-employed
North	0.1006***	0.1187***	0.0651*	0.0595*	0.2425***	0.0646**	0.0442
	(0.023)	(0.027)	(0.039)	(0.033)	(0.057)	(0.032)	(0.050)
South	-0.1458***	-0.0961***	-0.1686***	-0.0772**	0.0023	-0.2655***	-0.3025***
	(0.027)	(0.034)	(0.046)	(0.038)	(0.070)	(0.036)	(0.059)
Private	-0.0845***	-0.1619***	-0.0694*	-0.0625*			
	(0.012)	(0.014)	(0.036)	(0.034)			
Part-time	-0.6440***	-0.5145***	-0.5826***	-0.5718***	-0.4604***	-0.2742***	-0.2830***
	(0.034)	(0.015)	(0.147)	(0.040)	(0.080)	(0.078)	(0.054)
Secondary	0.0507***	0.1402***				0.1926***	0.1990***
	(0.019)	(0.025)				(0.026)	(0.043)
Immigrant	-0.2228***	-0.2118***	-0.4556***	-0.3970***	-0.4060***	-0.0313	-0.2395**
	(0.020)	(0.032)	(0.074)	(0.081)	(0.139)	(0.079)	(0.110)
Age	0.0336***	0.0147***	0.0736***	0.0493***	0.0247***	-0.0029	0.0340**
	(0.004)	(0.005)	(0.015)	(0.012)	(0.005)	(0.010)	(0.017)
Age squared	-0.0004***	-0.0002***	-0.0006***	-0.0004***		0.0001	-0.0004**
	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)
Contributions	0.0120***	0.0154***	0.0024	0.0111***	0.0396***	0.0060**	0.0082**
	(0.001)	(0.002)	(0.004)	(0.003)	(0.011)	(0.003)	(0.003)
Contributions squared					-0.0009***		
					(0.000)		
Secondary*Contrib.	0.0086***	0.0079***					
	(0.001)	(0.001)					
North*Contributions	-0.0032***	-0.0034**					
	(0.001)	(0.001)					
South*Contributions	-0.0003	0.0012					
	(0.001)	(0.002)					
Women					-0.1621***		
					(0.054)		
Atypical					-0.0002	-0.2127***	-0.1089
					(0.062)	(0.077)	(0.070)
Constant	6.7337***	6.9234***	6.0849***	6.4061***	6.5138***	7.3012***	6.4038***
	(0.076)	(0.100)	(0.330)	(0.244)	(0.169)	(0.209)	(0.332)
Observations	7478	5349	1005	1169	911	2627	1124
R^2	0.334	0.427	0.293	0.349	0.265	0.112	0.119
Adjusted R^2	0.333	0.426	0.287	0.344	0.258	0.109	0.111
Res. sum of squares	1154	915	258	247	477	1136	510
RESET (p-value)	0.155	0.171	0.259	0.213	0.529	0.434	0.458
RESET (p-value)	0.6852	0.4375	0.5726	0.4482	0.5171	0.8156	0.6057

Note: Standard errors robust for heteroschedasticity in parentheses. * p<.10, ** p<.05, *** p<.01. Reference group: men (when both sexes are included), primary school, Italian citizen, working full-time, living in Central Italy, non-atypical worker, working in the public sector. The RESET test is conducted testing the joint significance of the square of fitted values, using a heteroschedasticity robust F test.

Source: Ciani and Morciano (2011)

Table 9: Panel estimates earnings equation, Euros 2006

	Men, not graduated, employees	Women, not graduated, employees	Men, graduated, employees	Women, graduated, employees	Graduated, self-employed	Men, not graduated, self-employed	Women, not graduated, self-employed
North	0.0625***	0.0804***	0.0087	0.0555**	0.1049**	0.0535**	0.0532
	(0.014)	(0.016)	(0.028)	(0.023)	(0.049)	(0.023)	(0.039)
South	-0.1137***	-0.1029***	-0.1404***	-0.0393	-0.0543	-0.2483***	-0.2949***
	(0.015)	(0.019)	(0.031)	(0.026)	(0.056)	(0.026)	(0.047)
Part-time	-0.2892***	-0.2823***	-0.1701***	-0.2361***	-0.3922***	-0.1936***	-0.1835***
	(0.010)	(0.007)	(0.032)	(0.017)	(0.042)	(0.034)	(0.032)
Secondary	0.0692***	0.1634***				0.1164***	0.1196***
	(0.010)	(0.013)				(0.017)	(0.032)
Age	0.0504***	0.0270***	0.0890***	0.0368***	0.0162***	0.0561***	0.0190
	(0.002)	(0.003)	(0.009)	(0.008)	(0.003)	(0.007)	(0.014)
Age squared	-0.0005***	-0.0003***	-0.0008***	-0.0002**		-0.0006***	-0.0002
	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)
Years spent in paid work	0.0002	0.0016**	0.0002	0.0001	0.0115*	0.0014	0.0028
	(0.001)	(0.001)	(0.001)	(0.001)	(0.006)	(0.001)	(0.002)
Years spent in paid work squared					-0.0003**		
					(0.000)		
Secondary*Years spent in paid work	0.0033***	0.0034***					
	(0.000)	(0.001)					
North*Years spent in paid work	-0.0009	-0.0012					
	(0.001)	(0.001)					
South*Years spent in paid work	0.0006	0.0019**					
	(0.001)	(0.001)					
Women					-0.1560***		
					(0.044)		
Year==2004	0.0166***	0.0212***	0.0169	0.0094	0.0031	0.0224	0.0186
	(0.005)	(0.007)	(0.016)	(0.016)	(0.043)	(0.019)	(0.032)
Year==2005	0.0036	-0.0068	0.0285*	0.0063	0.0261	0.0341*	-0.0053
	(0.005)	(0.008)	(0.016)	(0.017)	(0.043)	(0.019)	(0.033)
Year==2006	-0.0010	-0.0074	0.0594***	0.0353**	0.0711	0.0354*	-0.0239
	(0.006)	(0.008)	(0.017)	(0.017)	(0.043)	(0.019)	(0.034)
Year==2007	-0.0153**	-0.0151*	0.0212	-0.0044	0.0660	0.0612***	0.0178
	(0.006)	(0.009)	(0.019)	(0.019)	(0.047)	(0.021)	(0.037)
Constant	6.0714***	6.2791***	5.4221***	6.2621***	6.7279***	5.9161***	6.4171***
	(0.044)	(0.060)	(0.181)	(0.160)	(0.123)	(0.146)	(0.281)
Observations	21583	15335	2701	3286	1881	7317	2698
σ_μ	0.240	0.242	0.317	0.285	0.453	0.399	0.427
σ_ξ	0.185	0.222	0.194	0.213	0.410	0.369	0.396
ϱ	0.322	0.346	0.249	0.282	0.123	0.171	0.237
$\sigma^2_\varepsilon = \sigma^2_\mu + \sigma^2_\xi$	0.092	0.108	0.138	0.127	0.373	0.295	0.339
RESET (p-value)	0.2508	0.6416	0.7302	0.3768	0.0047	0.231	0.4233

Note: Standard errors robust for heteroschedasticity in parentheses. * p<.10, ** p<.05, *** p<.01. Reference group: men (when both sexes are included), primary school, working full-time, living in Central Italy. The RESET test is conducted testing the joint significance of the square of fitted values, using an heteroschedasticity robust F test.

Source: Ciani and Morciano (2011)

$$\delta(s,t) = \frac{\sigma_\mu^2 + \rho^{|s-t|}\sigma_\xi^2}{\sigma_\mu^2 + \sigma_\xi^2} \tag{11}$$

The model implies that we can project the conditional mean of log-earnings in any future period s of the microsimulation model using the covariates z_{it} in that period, the residuals $(y_{i0} - z_{it}\beta)$estimated for the worker in the initial population (denoted with subscript *0*), and the estimates for $\delta(s,t)$. Intuitively, when we predict log-earning in period s we take into account the individual residual, as estimated in period t, but we assign to it a weight that declines with the distance between t and s.

Parameters in equation (10) can be retrieved from the panel estimates, whereas the deterministic component of the earning equation can be obtained using a cross-section. Panel estimates shows a value of ρ ranging from 0.067 to 0.208; σ_μ ranging from 0.249 to 0.569 and σ_ξ ranging from 0.430 to 0.518.[39]

A further problem in generating stochastically earnings for the simulated period is that the composite error term ε_{it} , is unavailable for those who the information on earning is not available at the time of the interview (in work and not respondent; temporarily not in work). Assuming normality we compute this term extracting a random number from a normally distributed function with mean zero and variance $\left(\sigma_\mu^2 + \sigma_\xi^2\right)$.

Finally, y_{is} is multiplied by a factor allowing the individual earning in s to be linked to the medium-long term productivity growth. The model allow to set different exogenous assumption on productivity. However, there is one point which needs to be made clear: the ageing of the Italian working force and the increase in the stock of human capital in the coming decades increase the average earning level, since age and education have a positive effect on average labour earnings. However endogenous growth produced by the module does not account for the expected increase in productivity. In order to avoid over/under-estimations of earnings growth rates for the coming decades, a pro-quota growth factor τ_s is added to the endogenous growth annually determined by the module. Formally:

[39] It is not straightforward tasks to assess to which extend these values are reliable or not. Comparable results can be found in Ramos (2003), who found for the UK (period 1991 to 2002) parameters quite similar to those founded by Lillard and Willis (1978) using the American PSID panel. The most detailed and reliable analysis for Italy has been carried out by Borella (2001) and Borella and Moscarola (2010). Contrasting our results with the latter, we found slightly higher values for the variance of the residuals, in particular for the standard deviation of the time varying error component. Interestingly, for self-employed the correlation term ρ is quite consistent with the result from Borella and Moscarola (2010), whereas it seems to be appreciably underestimated in our case. This is possibly due to the short length of the IT-SILC panel, as the fraction of individuals observed for the maximum number of four years is still quite limited. However, it should be noticed that the earning module buit in CAPP_DYN is fully flexible in the choice of these parameters.

$$\tau_s = m_s - \left[\frac{E(y_s)}{E(y_{s-1})} - 1\right] \tag{12}$$

where m is the expected earning growth whereas the second term in (13) measures the earnings growth endogenously determined by the module. Annual terms of m can be set exogenously (i.e. using projections made available by the Italian Department of General Accounts (RGS, 2011)) or determined in a routine embedded in the model as the difference between the yearly GDP and the yearly growth rate of the labour force (n):

$$m_s = GDP_s - \left[\frac{n_s}{n_{s-1}} - 1\right] \tag{13}$$

7 The social security module

The (theoretical) long-term characteristics of the Italian pension system have been radically modified during the reform process started in 1992 [40]. Before the reforms, the system was based on a DB mechanism: pension benefits P_{DB} were determined by multiplying pensionable earnings (W) by the number of working years (N) and by an accrual rate (α). The calculation rule of the first year DB pension benefit, can be approximately represented as:

$$P_{DB} = \alpha \cdot N \cdot W \tag{14}$$

Numerous schemes -each one with its own rule- were in place at the same time producing great heterogeneity in pension treatments. The system was unanimously considered financially unsustainable and unfair from a distributional viewpoint. In fact, the formula in equation (14) does not contain any form of actuarial adjustment with respect to the choice of the age of retirement. Moreover as W was computed as the average value of earnings recorded over the last five years before retirement the DB formula favoured steeper earnings carriers with respect to the flatter ones. Finally civil servants, self employed and workers in some other minor schemes were guaranteed more generous rules with respect to the main scheme. Some redistributive elements were allowed. In particular α was equal to 2% for the pensionable earnings bracket between 0 and 42,111 Euro and decreased with earnings level down to 1.1% for the pensionable earnings bracket over 55,976 Euro. To the contributions paid by workers, it granted an internal rate of return that was on average

[40] A detailed presentation and discussion of the Italian reform process of the pension system is beyond the scope of this paper. We refer to (Mazzaferro and Morciano, 2012) and our contributions in previous reports for a detailed presentation of the main reforms occurred in the recent years.

greater than the growth rate of the taxable base. Internal rates of return were higher for those retiring early and for workers with steep lifetime earnings profiles. Civil servants, the self-employed and workers in some minor schemes were guaranteed more generous rules with respect to the main scheme, the one in force for private dependent workers. Although the legal retirement age was set at the age of 60 for men and 55 for women, early retirements (seniority pension) were allowed on reaching a minimum period of contributions of 35 years (for the main scheme).

Under the pressure of the financial crisis of the Italian currency (*Lira*) and of the urgency to cut the public deficit, the first step of the reform process was a standard parametric one (the so-called "Amato reform") which starting from 1993: *i)* increased the legal retirement age; *ii)* increased the number of years over which pensionable earnings were to be calculated; *iii)* cut α in the DB pension formula; *iv)* introduced a gradual harmonization of pension rules among categories; *v)* modified indexation of pension benefits linking their growth to inflation in lieu of earnings.

Three years later, the Italian Parliament approved a law (L.335/95) that introduced a Notional Defined Contribution (NDC) system which more closely linked individuals contributions with pension benefits, and credited future benefits with a sustainable rate of return. Contributions are (fictitiously) accumulated in an individual fund, and are revaluated in line with a moving average of GDP growth. Under the NDC system, the first year pension benefit P_{NDC} can be represented as follows:

$$P_{NDC} = D_R \cdot MC_R \tag{15}$$

where D_R is an age related conversion factor, conditional on life expectancies at the age of retirement (R)[41] [42] ;MC_R is the total of contributions accrued at the age R during the whole working life capitalized at the rate of growth of GDP according to the formula:

[41] Such coefficients, uniform by sex and dynamically updated in order to take into account life-expectancy forecasts of new and future cohorts, allow the system to be (on average) almost actuarially fair among individuals belonging to the same sex and cohort.

[42] Caselli *et al.* (2003) approximate the conversion factor using the following formula

$$D_R \approx \sum_{t=0}^{T-R-1} \Big({}_t p_R \cdot (1+r)^{-t} \Big) + \beta \sum_{t=0}^{T-R-1} \Big({}_t p_R \cdot q^v_{R+t} \cdot z^F_{R+t+1} \cdot (1+r)^{-(t+1)} \Big),$$

where T is the maximum life span; ${}_t p_R$ is the pensioner's probability at age R of being alive at age $R+t$; r is the annual real discount rate (set equal to 1.5 per cent, assumed to be equal to the long-run annual growth rate of GDP in real terms); β (set equal to 0.54 for a male pensioner and 0.42 for a female one) is the fraction of the pension paid out the surviving spouse (if there is any); q^v_{R+t} is the probability of dying between age $R+t$ and age $R+t+1$; z^F_{R+t+1} is the expected present value of a real annuity of one Euro paid to the surviving spouse (if there is any) after the pensioner's death at age $R+t+1$.

$$MC_R = \sum_{t=a}^{R-1} c_t W_t (1+r)^{R-t}, \tag{16}$$

where a is the age at which individual enter into the labour market; r is the rate of growth of GDP; c_t the contribution rate to the pension scheme and W_t is gross earning in year t.

Retirement age in the 1995's reform was made flexible from 57 to 65 years conditional on a matured pension benefit higher than 1.2 times the minimum old-age allowance. Moreover, the speed of convergence to the NDC system was very slowly designed. Current and future workers were divided into three different groups with substantially different pension expectations. For people already contributed into their scheme at least for 18 years on the 1st January 1996, the pension level will continue to be calculated according to the old Defined Benefit (DB) method in equation (14). The NDC system (equation 15) only applies completely to those who started working after the 1st January 1996, whereas pensions for workers who started contributing to their scheme before 1996 but had less than 18 years of service on the cut-off date are calculated on the basis of a mixed formula: the periods before the 1st January 1996 are counted as earnings-related and the periods thereafter as contribution-related:

$$P_{mixed} = P_A + P_B \tag{17}$$

where the pension benefit P_{mixed} is determined as the sum of two components; the first component is P_A and it is computed according to the DB formula on the contribution paid before 1995[43], while the second, P_B, is computed according to a NDC rule on the after 1995 contributions.

The 1997 reform further reduced the heterogeneity of treatments between private and public employees, and posed additional restrictions for early retirement. In 2004 and 2007, governments tightened the eligibility conditions of retirement by raising the minimum retirement age to 60 for women and 65 for men, and by increasing the age and years of contribution requirements for seniority pensions[44]. The Law 122/2010 linked the age of retirement of all workers to the gain in life expectancy at age 65, starting from 2015.

[43] Nevertheless, in the mixed regime the pensionable wage for the contributions paid between 1992 and 1995 is determined differently, being computed as the mean wage over the years after 1992 indexed to 1% yearly rate according to a simple compounding rule.

[44] Starting from 2007, the Italian legislation formally requires the transfer of new flows of TFR (a severance payment that employers of the private sector have to pay to their employees) from companies book reserves to a pension fund, unless the employees explicitly forbid it. This rule, together with a strong fiscal incentive package for pension saving, was introduced to develop the tiny private pension pillar in Italy. Starting from 2010, the legal retirement age will also gradually be increased for women employed in the public sector to bring it in line with the age for men in 2012.

The last stage of the pension reform was carried out at the end of 2011, with the so-called "Monti-Fornero" reform. Similarly with what happened in 1993, both the financial crisis and fears about the sustainability of the Italian public finances forced the Italy's Parliament to approve changes to the pension system which include, apart the temporary freeze on the indexation of most pensions, higher retirement ages, more stringent requirements for seniority pensions, an extension in the minimum contribution period and other requirements to qualify for retirement. The normal retirement age is set to 66 years, having at least 20 years of seniority (against the previous requirent of 5 years). Early retirement are allowed only either upon reaching a work seniority of 42 years and three months (one year less for females) and 63 years of age. Age and work seniority requirements are now automatically linked to increasing life expectancy. For NDC pensioners, further conditions on the adequacy of the pension benefit need to be respected: normal (early) retirement is possible only having a pension which is at least 1.5 (2.8) times the social assistance pension. If the adequacy conditions are not fulfilled, retirement age will be postponed at 70, having at least 5 years of contribution. Besides, the Monti-Fornero reform accelerates the very slow down transition to the NDC system (introduced in 1995), by applying the NDC formula in equation 15 to *all* workers for the contributions accrued after 2011.

The social security module of CAPP_DYN tries, as far as possible, to take into account of much of the legislative changes synthetically described above. Individual retirement choices and the computation of old age and survivors pension benefits, as well as of social allowances, social assistance increases (*maggiorazioni sociali*) and supplements (*integrazioni al minimo*) are simulated in this module. Moreover, the module allows the simulation of the most important allowance and pensions available for disabled and invalid people.

7.1 Old-age pensions

Individual old-age pension benefits depend on the following variables:

1. the seniority of social security contribution at the moment of retirement;
2. the life-cycle profile of gross earnings
3. the assumptions on the macroeconomic growth during the period of pension contribution;
4. the contribution rate during working life;
5. the pension scheme;
6. the retirement age and the year of retirement.

(1) depends on the total amount of years the individual received a positive labour incomes; (2) depends on the dynamics of individual earnings and its determinants; (3) are set in the

"scenario block" whereas (4-6) take into account historical values and rules; for the future years, we assume that contribution rates and eligibility criteria for the retirement to be invariant with respect the rules approved in December 2011.

A necessary condition for retirement is the fulfillment the eligibility criteria, which are automatically updated on official life expectancy. CAPP_DYN embodies routines which allows the introduction of two types of behavioural reaction. The first checks whether-once eligibility criteria are fulfilled- the exit from the labour market is inter-temporally advantageous, in line with the Stock and Wise (1990) model. In practice, it compares two options: keep working one more year or exit immediately. If the net social security wealth is greater under the second option, then the retirement choice is effectively simulated, otherwise retirement is postponed until the above condition is reached. A second reaction function relates to the adequacy of the pension benefit. The constraint is based on the value of the gross replacement rate (i.e. the ratio between the pension that an individual accrue retiring at t and the last positive earning). If the value of the replacement rate an individual would obtain retiring at t is below a certain threshold (defined in the "scenario block")[45], the individual postpones retirement until the adequacy threshold is reached. CAPP_DYN is sufficiently flexible to allow the application of reaction functions to the entire sample of eligibles or to a subsample of them (i.e. only to those eligible for seniority pensions or those with a particular qualification or level of education/gross income).

7.2 Social assistance minimum pensions

Several supplementary benefits are provided to older people. In simulating all of them, CAPP_DYN follows the regulation in force in December 2011.

Pensioners in the DB or mixed regime are entitled to a (means-tested) minimum-pension supplement (the so-called *integrazione al trattamento minimo*, bringing the pension to 5,500-7,800 Euros per year (in 2011 Euro prices), depending on age. A special supplement (the so-called *maggiorazione sociale*) is aiming at guaranteeing a minimum income level for older pensioners. This benefit can be claimed by those age at least 70, with a possible age reduction according to the contribution seniority. A non-contributory Social Allowance (SA) are available for older Italian citizens who are older than 65 (increasing in the future together with statutory retirement age, according the Monti-Fornero reform). The amount of the so-called *assegno sociale* is currently fixed at (5,600 euro per year) being subject to means-testing: in means test formula, also the social security pension enters, although with a deduction of 1/3, within the limit of 1/3 of the social assistance pension itself. also the social security pension enters, although with a deduction of 1/3, within the limit of

[45]The choice of the particular threshold value adopted is clearly sensitive with respect the determination of the actual mean age of retirement and the computational formula in use.

1/3 of the social assistance pension itself. Formally, for an individual single in 2012:

$$SA = max\{0; 5,592.8 - [y - min(1/3 \cdot P; 1/3 \cdot 5,592.8)]\} \tag{18}$$

where P is the amount of old-age or seniority pension; y is a comprehensive measure of income used for the means-test which includes P.[46]

7.3 Survivors and indirect pensions

The death of a pensioner or of a worker with at least 5 years of contribution seniority entitles the survivors to benefit of survivors (the so-called *pensione di reversibilita'* and indirect pension *pensione indiretta* respectively. Pension benefits are computed following as far as possible the regulation in force in December 2011. Once the pension benefit the death person was entitled for has been determined, it is shared and assigned to every single components of the household accounting for their economic conditions. In particular, the model distributes the total amount among the survivors assigning: 60% to the spouse; 20% to each child in case the spouse is alive; 40% to each child in case the spouse is not alive. The sum of the share cannot exceed the 100% of the pension the retired would be entitled for. If one child is entitled only, the share is set at 70%. Survivor and indirect pensions are means-tested: the allowance is reduced by 20%, 40%, and 50% in case the income earned by the beneficiary exceed by 5, 4, 3 times respectively the amount of the minimum pension benefit. The last rule is not applied in case underage students or disable children are co-entitled. The amount of those who have paid at least 20 annuities of contribution but did not reach the minimum pension amount are topped up to the minimum level.

7.4 Disability and invalidity pensions

The social security module selects beneficiaries of disability allowances (*indennita' di accompagnamento*, disability and civil inability pensions (*pensione di inabilita'* and *pensione di invalidita' civile*), given the disability status (and its severity) simulated with the procedure described in the section 5. The most important and widespread governmental non mean-tested cash disability benefit is the *indennita' di accompagnamento* originally intended for adult disabled people, but extended to older people in the mid-1980s. A flat amount (in 2012, 492,97 Euros per month) is provided to those extremely disabled and in need of continuous care.

The *pensione di inabilita'* is determined according to the standard system of old-age pension computation depending on the pensionable earnings and on the contribution seniority

[46] See Marano, Mazzaferro, and Morciano (2012) for a detailed description of the eligibility criteria and computational formula for SA.

of the insured. A disabled can claim the full amount (256.67 Euros per month in 2010) if the household income is lower than 15,154.24 Euros per year (2010). The disability pension amount consists of two components: one share is determined according to the pensionable earnings and to the contribution seniority as for the inability allowance, while the remaining part is determined by the difference between the inability allowance and the pension she/he could benefit should she/he had accrued a seniority increased by a period amounting to the difference between the year the inability allowance started to operate and the retirement age (with a dispensation to disabled persons at least for the 80%). Seniority cannot exceed 40 years. For those in the NDC system, the sum of contributions accrued is added to a share of contributions for the gap period between the pension starting year and the 60th birthday. Again, seniority cannot exceed 40 years. Pensioners which have paid at least 20 annuities of contribution but did not reach the minimum pension amount are topped up to the minimum level. Finally, a worker can claim the *pensione di invalidita' civile* if is moderate-severe disabled and in need of care. A disabled can claim the full amount (256.67 Euros per month in 2010) if the personal income is lower than 4,408.95 Euros per year (2010). No seniority above the 40 years will be considered. Both the *pensione di inabilita'* and the *pensione di invalidita' civile* can be cumulated with the *indennita' di accompagnamento*. The amount of the latter does not account for the means-test.

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